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phyllites, Neuropteris, Alethopteris, Megalopteris, Pecopteris, Whittleseya and *Sigillaria*.

DAVID WHITE

PROFESSOR PUNNETT'S ERROR

IN Professor Punnett's admirable little book, entitled "Mendelism," there occurs an error of definition that ought not to go unnoticed. This error, which runs through the whole book, begins on page 2, where may be found this statement: "Among animals the female contributes the ovum and the male the spermatozoon; among plants the corresponding cells are the ovules and pollen grains."

The last half of the quoted sentence contains three distinct errors: (1) Half of the plant kingdom possesses no pollen grains nor ovules, yet its members have parts that correspond with the ova and spermatozoa of animals; (2) the ovules and pollen grains are not *cells* but each is a cell complex; (3) it is a gross mistake to regard the pollen grains and ovules of plants as corresponding with the spermatozoa and ova of animals.

The first two mistakes might be passed over; but the third, in a book that is written for the reading public, is unfortunate and should be corrected in the next edition. The pollen grain is multicellular and the ovule is multicellular. The genetic cells of higher plants are produced in these bodies. It is as correct to call the testis of an animal a gamete as to call a pollen grain a gamete. The terminology of the genetic cells in plants need offer no difficulty to the zoologist. If he will consult the literature, or his botanical friends, he will find that, besides using the term *gamete* for the conjugating cells of both plants and animals, he may use *ovum* and *spermatozoon* for plants as well as for animals.

F. C. NEWCOMBE

PHENOMENA OF FORKED LIGHTNING

As pointed out in a recent paper in *SCIENCE*, September 1, the negative end of a lightning discharge is forked. When visible we call it forked lightning. When such a system of drainage channels penetrates a shower of nega-

tively charged drops, great differences in potential between drops not far removed from each other must be created. Before the flash the drops have approximately equal potentials. They then repel each other. Drops having radii of one mm. only need to be charged to a potential of 0.0031 volt in order that their repulsion for each other may balance their gravitational attraction.

As soon as the flash occurs these drops attract each other. They coalesce, and a brief dash of large drops of rain follows.

FRANCIS E. NIPHER

SCIENTIFIC BOOKS

A Study of Chiriquian Antiquities. By GEORGE GRANT MACCURDY. Memoirs of the Connecticut Academy of Arts and Sciences, Vol. III., March, 1911. New Haven, Conn. Pp. 249, 384 text figures, 49 plates.

In a beautiful volume Dr. MacCurdy has given us the fruits of a long and patient investigation of the excellent collection of antiquities from Chiriqui in the Museum of Yale University. Not too much praise can be given to the painstaking examination and clear description of the long series of specimens, to the careful grouping of the material, which makes it possible for the student to master the wealth of new material with comparative ease. The author's description is about the same as that given by Holmes, but with a few modifications in terminology and grouping. Together with Professor Putnam's paper on conventionalism in ancient American art, and Professor Holmes's earlier description of ancient art of the province of Chiriqui, we have here material that needs only the additional researches of the field investigator to give us a clear picture of the archeology of a part of the Isthmian region. It is fortunate that, for a comparison of cultural types, the archeologist has at his disposal the two careful investigations by Dr. Hartman on the eastern and western parts of Costa Rica.

The illustrations in Dr. MacCurdy's volume are of the excellence of all the work of Mr. Rudolf Weber, whose illustrations of the publications of the Heye Expedition and for-

merly of the publications of the American Museum of Natural History have won him well-merited recognition on the part of the students of anthropology.

The author treats in detail work in stone, pottery and work in metals. The principal part of the work is devoted to a discussion of pottery forms and decoration, and the work must be considered an important contribution to the study of decorative art. I think in this lies its greatest interest.

Although the author does not commit himself quite definitely in regard to any theory of the development of art, his inclination, as exhibited in the detailed discussion of specimens, is clearly to consider geometrical ornament as developed by conventionalization of realistic motives, and he seems to consider this process as occurring by an inner necessity. "If the line of art development were plotted, it would probably be found to rise rather suddenly to the acme of realism, and then drop slowly to about its original level. The accompanying series of illustrations, however, does not begin at the beginning, but rather at the crest of the realistic wave, and descends gradually to the trough, probably that one lying on the conventional side; yet some of the stages shown might just as well be steps in the ascending as in the descending scale. In other words, a definite chronological sequence has not yet been established" (p. 57). Still in the next sentence the author states that there are reasons for considering realistic animal forms as preceding conventionalized forms, but I have not been able to find these reasons. Only in the case of the transformation of simple forms of objects into life forms does he admit the inverse process. "We have now followed the various steps in the development of the complete zoomorphic unit from the commonplace mealing stone" (p. 30). "It did not require a wide stretch of the imagination to arrive at the zoomorphic possibilities of the plain tripod leg. By the application of nodes and pellets of clay to the hollow tripod supports they immediately assume animal forms" (p. 51).

The difficulty in proving or disproving these

theories lies in the fact that the material studied is not dated, that we do not know whether some forms are older than others, or whether all belong to the same time. That changes of artistic style have occurred in these areas is more than likely, notwithstanding the meagerness of proofs of cultural sequences on our continent. Dr. Spinden's demonstration of changes in the technique of an art style in Central America, the analogous phenomena observed among the cruder civilizations of the northwest coast, are important from this point of view which should receive the closest attention of archeologists.

It seems to the mind of the writer that the chief objections to the attempted interpretation of the development of an artistic style from a study of the undated object alone lie in the formal character of the treatment of the problem. Dr. MacCurdy, like his predecessors, has given us a careful classification of form and ornament, arranged according to considerations of technique, and of greater or less complexity of form. Among these he selects the forms which seem most plausible as the starting point of the series and the rest are then arranged in order, a time sequence being substituted for a series based on similarities of form. It may be that the investigator happens to strike the correct arrangement, but, considering the complexity of the problem and the possibilities of development in various directions, the probability of having reached a true historical explanation is not very great.

Dr. MacCurdy sums up the series of processes that lead to conventionalization as due to reduplication, exaggeration, elimination or fusion of parts of units; transposition, shifting and substitution; isolation of parts and their use independently of the whole; wholesale reduction and simplification; adaptation to fit a given space (pp. 127, 229). All these may occur, but they do not prove a historical development, because they are merely an enunciation of the principles of classification or seriation chosen by the student.

Wilhelm Wundt, in his *Völkerpsychologie*,

has pointed out that in our studies of development of art the psychological processes of the artist are the essentials for a clear understanding of the history of art, and I think this point of view must be kept in mind constantly if we desire to understand the history of art development.

For this reason it seems to me that the purely classificatory method, as followed by Dr. MacCurdy as well as by previous students, is not likely to give us the desired clue. Neither can it be found in ethnological inquiry and the most copious explanatory notes, which must always be open to the suspicion of having been read into the designs by the natives.

We have to bring before our minds more clearly the procedure of the native artist, the conditions under which he works and the extent of his originality. The term conventionalization, which we so readily employ, should be taken in a stricter sense, and we must understand what happens in the mind of the artist—including under this term unconscious processes—who either conventionalizes a realistic representation or develops a realistic form out of a geometrical form. Thus the problem presents itself of discovering the fundamental art forms that exert a domineering influence over the artist.

From this point of view, it seems to my mind that the first element to be determined is what is stable in each art form. Dr. MacCurdy does this in his careful classification of the material; and the association between lack of painting and presence of attached decorative elements modeled in the round,—a conclusion which I think has quite a general validity;—the presence of painting and lack of relief decoration; and other more detailed characteristics of certain forms, like the presence of the rim in vessels with neck decoration are brought out clearly.

The next step in the discussion of the ware with attached ornaments, however, does not seem to me well taken. Dr. MacCurdy points out the great frequency of armadillo-like forms, and the peculiar character of carapace,

foot, eye and tail ornaments. From these he concludes, if I understand him rightly, that the life motive is older than the elements just described, which are derived from it. The relationship of the ware with relief decoration to analogous types of neighboring districts does not seem to me to favor this view. It is the essential characteristic of all this ware, that the decorative elements consist of small nodes or fillets which are applied to the surface of the vessel or to some of its parts, like feet, neck, shoulder or handle; and which are decorated by a series of short parallel impressions. An oval node with single medial lines is often used to indicate an eye; a similar nodule with a number of parallel lines indicates the foot, a series of parallel, short fillets with parallel short crosslines, are applied to the bodies of animal forms, but also to the bodies of vases. Hartman¹ describes analogous technical motives from Chiricot and Orosi in Costa Rica (for instance Pl. 22, Fig. 2; Pl. 27, Fig. 2; Pl. 37, Figs. 5, 6; Pl. 39, Fig. 1; Pl. 51, Fig. 8; Pl. 64, Fig. 7) which in technical character are so much like the Chiriqui specimens that we can hardly doubt that they are derived from the same device. It might seem that this method of decoration is so easily discovered that little weight can be attached to it. Its extended use in South and Central America and in the West Indies² is, however, quite characteristic of that area. In North America it is not common, except in the Gulf region.³ In contrast with its frequency in the highly developed pottery of Central America its almost complete absence may be noted in Africa, where highly decorated pottery forms are by no means absent, and where lids with animal figures might seem to suggest readily

¹ C. V. Hartman, "Archeological Researches in Costa Rica," Stockholm, 1901.

² See, for instance, W. J. Fewkes, "The Aborigines of Porto Rico," 25th Annual Rep. Bur. of Amer. Ethnology, Fig. 36, p. 185; Pl. 76, Fig. c; Pl. 78; Pl. 79.

³ G. P. Thruston, "The Antiquities of Tennessee," p. 146; Pl. 7; W. H. Holmes, "Aboriginal Pottery of the Eastern United States"; for references see index under "fillets" and "nodes."

the application of the device.⁴ This is true also of the prehistoric pottery of Europe. Only in the slip (barbotine) decorations of the terra sigillata do we find anything resembling the American appliqué ornamentation, but since the material is applied in a semifluid state, it does not attain the same freedom of treatment. Nodes that do occur in European prehistoric pottery seem to have been made rather in imitation of punched bronze decorations and belong to a late period. Attached animal figures, made in clay, like those found at Oedenburg, also seem to be imitations of metal work and have never reached that development which is so characteristic of Central American ceramic art.⁵

The characteristic slit rattle feet of Chiriqui pottery prove even more conclusively than the application of fillets and nodes, that the art forms of this province must be considered as a special development of forms characteristic of a much wider area. This type of foot is so well known that no special reference to its occurrences outside of the Chiriqui territory need be given.

We are thus led to the conclusion that the armadillo motive of the author is historically related to the method of decorating and building up vessels from separate pieces, nodes and fillets, the nodes and fillets being in many regions decorated by parallel incised lines, or by dots. If this is true, the armadillo motive can only be a specialized application of the building up of animal motives from the elements in question, and neither can the elements themselves be considered primarily as symbols of the armadillo (p. 61), nor can all the animals built up of these elements be interpreted as armadillos.

⁴ "Notes analytiques sur les collections ethnographiques du Musée du Congo," Vol. II., "Les industries indigènes"; Part 1, "La céramique." (Fig. 293 *a* is the only one that may exhibit this technique.)

⁵ Relief ornaments consisting of fillets have been described from northern Germany, Bohemia, Bosnia and Italy. See, for instance, Radinsky, Butmir, Vienna, 1895; K. Koenen, Gefässkunde, Bonn, 1895, Pl. III., Fig. 12.

For the same reason I am inclined to doubt the correctness of the interpretation of the alligator group, which was first given by Professor Holmes in the work before referred to. The upturned snout, of which much is made as a means of identification, is a character of much wider distribution than the alligator motive. The monkeys on Plates 27 and 32*a* of Dr. MacCurdy's book have it, and we find it as well in the interior of Costa Rica⁶ as in parts of South America. This is no less true of the curious "nuchal appendage" which occurs in Costa Rica⁷ as well as in South America,⁸ and of the dotted triangle.

It seems to me that the essential point of this consideration lies in the technical and formal motives that are common to a large area, although differing in details in its provinces. These are the materials with which the artist operates and they determine the particular form which a geometrical motive or a life motive takes. If the notched fillet and node are the material with which the hand and the mind of the artist operate, they will occur in all his representations. If the conventional outline of the animal body has a definite form, all animals will tend to be represented in that manner. I have tried to emphasize at a previous time⁹ the importance of such fixed traditional forms in determining the conventional style of decorations.

In his further descriptions of the art work of Chiriqui Dr. MacCurdy notes the similarity of motives used in metal castings, notably

⁶ Hartman, *l. c.*, Fig. 2, Pl. 35, Pl. 81, Fig. 286, p. 128. The region in question has more frequently a proboscis-like appendage, rolled downward.

⁷ Hartman, *l. c.*, Fig. 2; Pl. 35.

⁸ M. H. Saville, "Contributions to South American Archeology." The George G. Heye Expedition. "The Antiquities of Manabi, Ecuador," Pl. 8. See also E. Seler, "Archäologische Untersuchungen in Costarica," *Globus*, Vol. 85, 1904, p. 237.

⁹ Notes to G. T. Emmons, "The Chilcat Blanket," *Memoirs of the American Museum of Natural History*, Vol. III., Part 4, pp. 355 et seq.

in the gold castings, and the armadillo pottery, a similarity which consists essentially in the use of detached figures, nodes and fillets, as described before. He also calls attention to the frequent occurrence of the head with up-turned snout—the alligator-head design of painted pottery—in this technique, a feature that had escaped the attention of previous students. At least one of them has, however, the type of proboscis rolled down (Pl. 58, Fig. g) which is so common on the plateaus of Costa Rica. In this case also the rigidity of the fundamental form seems particularly suggestive to the writer, because a variety of animals have all been presented in analogous outlines.

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Principles of Chemical Geology. A review of the Application of the Equilibrium Theory to Geological Problems. By JAMES VINCENT ELSDEN, D.Sc. (London), F.G.S. London and New York, Whittaker and Co. 1911. 222 pages, with 44 figures.

While an imaginative geological writer has recently asserted that “to be more productive than it is, geology must become more speculative,” it is gratifying to note the steady advance that is being made in the explanation of geological phenomena along the lines of established principles in the fundamental sciences of physics and chemistry. With the rapid development of physical chemistry there has been a corresponding improvement in conceptions regarding processes that have taken part in the production of the earth as we know it. And every effort that is made to place these fundamental concepts within the reach of students of geology, and which succeeds as well as the book before us, should be welcomed as a contribution of the first order to the advancement of the science.

But it must be borne in mind that any developing branch of human knowledge is an assemblage of observations and conclusions of variable degrees of accuracy and truthfulness, subject to constant revision and readjustment. And in the problem of the application

of principles of physics and chemistry to the phenomena of the earth, as a whole, and in detail, these are the variable factors of divergent opinion regarding the laws to be applied, and the still very inadequate data relating to the phenomena to be explained, as well as an accumulation of conflicting observations and of conclusions, in some instances misleading or actually incorrect. Moreover the multitudinous requirements in each branch of learning prevent the worker generally from acquiring independent judgment in more than one distinct branch of science.

For these reasons each contribution to the solution of the highly complex problems to be found in the study of rocks and minerals must have its particular characteristics arising from the point of view and range of experience of its author, as well as from the source of his information and the quality of his judgment.

In the contribution made by Mr. Elsdén there appears to be the experience of a physicist familiar with the subject of physical chemistry, and capable of presenting the essential principles in a clear and simple manner, not wholly free, however, from the technology of the science. There is less of the chemical side of the subject than the title of the book suggests, which might better have been “Principles of Physical Chemistry Applied to Geology,” for there are phases of the chemistry of the earth not touched upon. The application of the principles discussed is well made in most cases, and the examples that may illustrate them are happily chosen from the mass of recorded observations to be found in the literature of geology and petrology. In the selection and rejection of conflicting opinions in certain instances the author's judgment has been on the side of the more probable—according to the opinion of the reviewer. But the author does not appear to possess personal knowledge of the petrographical and mineralogical data appealed to in illustration of particular principles.

The author states that one of the main objects he has had in view is to show that the